PE Fuel Cells: Evaluation of Concepts for a Bipolar Plate Design and Construction

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The performance of the electrochemical components and the design and characteristics of the bipolar plate are the main parameters determining the performance of a PE fuel cell stack with respect to specific power and volume.

Therefore, the bipolar plate needs to be optimized with respect to material, design, and manufacturing process. Six concepts of bipolar plate constructions, different with respect to cooling system, construction material and gas flow design have been evaluated. Two of the concepts, which were considered as most promising were realized as prototypes and tested : (i) a bipolar plate made from a composite carbon fiber/epoxy material with internal air-cooling and (ii) a bipolar plate made from grafite-polymer mixture, composed from two half-plates allowing internal water cooling.

Plates based on concept (i) were light-weight and showed excellent mechanical strength, however with this type of material the electrical conductivity could not be optimized to the necessary low values. Plates based on concept (ii) fulfilled the requirements with respect to heat and electric conductivity, mechanical strength and corrosion resistance.

Internal plate cooling is an elegant way for liquid cooling (see Fig.1). If all plates are cooled internally then the heat variation in the stack can be easily controlled. To provide the cavity for the cooling fluid in the middle of the bipolar plate, the plates are composed from two half-plates of a thickness of 1.5 mm each. The half-plates were united by a gluing process in order to make the complete plate tight for the fluids with respect to leaks to the exterior and between the different fluids.

Half-plates were produced by SGL Carbon Group (Germany), and processed into complete bipolar plates at ETH. A complete bipolar plate has a thickness of less than 3.1 mm and a weight of approximately 125 g for 200 cm^2 active area. A 100 cell stack was completed for testing PSI. The pitch of a repetitive unit is 3.25 mm.
The current/voltage and current/power characteristics are shown in Fig. 3. The specific power and volume of this stack at nominal (not maximum) power of 6.4 kW are 330 W/kg and 430 W/l, respectively.

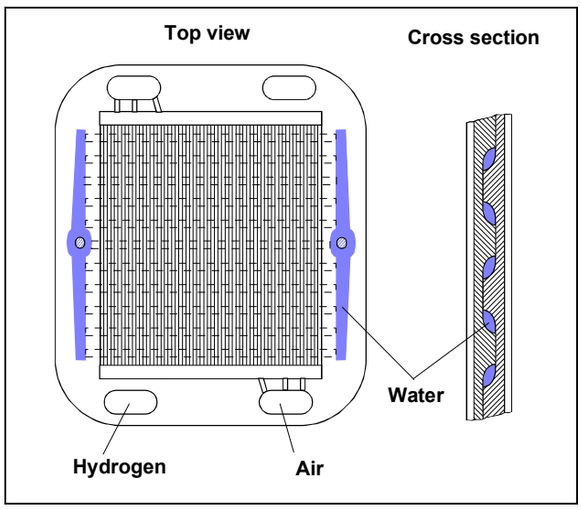

Fig. 1: Scheme of concept (ii) bipolar plate with internal liquid cooled, composed from two half plates.

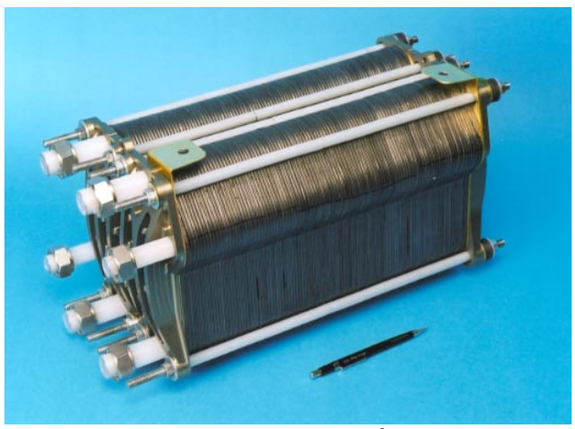

Fig. 2: 100 cell, water cooled, 200 cm^2 active area PEFC stack. Gross dry weight 19.5 kg, volume 14 l.

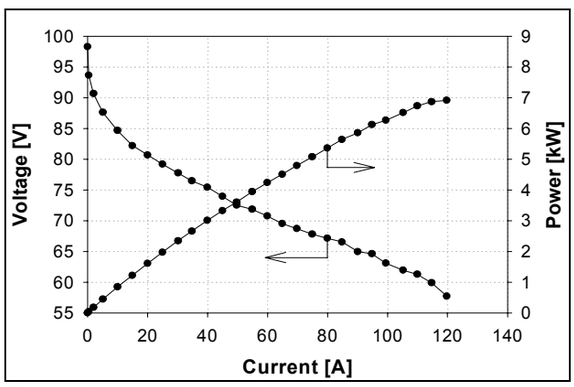

Fig. 3: Current/voltage and current/power characteristics of the 100 cell stack operated with pure H_2 and air. Stack temperature 70 °C, air stoichiometry 2.0; gas pressures 2.0 bar abs.